

¹⁴C DISTRIBUTION IN ROOTS FOLLOWING PHOTOSYNTHESIS OF THE LABEL IN PERENNIAL PLANTS IN THE NORTHERN MOJAVE DESERT

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ABSTRACT.— In April and May of 1973, 24 individual plants were exposed to ¹⁴CO₂ with techniques used in our other studies in the field. Seven to 8 months later, part of the plants were excavated and counted by plant part for ¹⁴C. The remainder of the plants were excavated at 13 months. The results indicated that from 3 to 20 percent of the carbon for leaves in the next year came from stems and roots of *Grayia spinosa* (Hook) Moq., *Ceratoides lanata* (Pursh) J. T. Howell, *Atriplex confertifolia* (Torr. & Frem.) S. Wats., *Lycium pallidum* Miers, *Ambrosia dumosa* (A. Gray) Payne, and *Acamptopappus shockleyi* A. Gray. Nearly all of the root segments were labeled at sampling time; however, some of the roots were labeled at higher amounts than others. Some roots had very little ¹⁴C, and these are assumed to be very new roots rather than dead roots because of their small size. The roots with high levels of ¹⁴C are assumed to be formed near the time of labeling, and those with low levels to be formed after the time of labeling. From 17 to 65 percent of the ¹⁴C fixed was recovered after 7 to 13 months.

INTRODUCTION

¹⁴C techniques have been used in studies of carbon allocation in desert plants and of root growth and distribution (Caldwell et al. 1974, 1975, 1976, Bamberg et al. 1973, 1974). One of the questions which arose in those studies is the nature of root labeling when a single labeled pulse is fixed in photosynthesis. Much can be deduced from the nature of carbon allocation according to the manner in which a single pulse of ¹⁴C is distributed within the plant. The major purpose of this study was to determine the distribution of ¹⁴C in individual roots and in segments of those roots following a single exposure to ¹⁴CO₂ of the shoots of plants growing in the desert. Another purpose was to ascertain the proportion of new growth in the springtime that arises from retranslocation from old parts of winter deciduous plants. The specific activity of ¹⁴C in the new shoot growth compared with that in the old parts could result in an estimate of the portion of the new growth that is parasitic on the old parts versus the fraction which comes from new photosynthesis. It is recognized that this approach could only indicate a minimum of the fraction coming from old parts. The ¹⁴C then would underestimate because it is not uniformly mixed with all the labile pool carbon. Another pur-

pose in this study was to ascertain if new roots could be identified by absence in them of labeled ¹⁴C in the year after its application.

MATERIALS AND METHODS

In May 1973, 24 perennial plants in Rock Valley and Mercury Valley, Nevada, were exposed to ¹⁴CO₂ with the technique previously used in these studies (Bamberg et al. 1973, 1974, Wallace et al. 1974). Briefly, at about 0900, four *Ambrosia dumosa* (A. Gray) Payne plants were covered with transparent plastic bags of 2 mil thickness, and 125 μ Ci ¹⁴CO₂ were released into each bag. Considerable water vapor condensed on the inside of the bags. Two hours later the bags were removed, and leaf and stem samples were taken from each plant for determination by Q-gas counting of the amount of ¹⁴C fixed, using the technique of Hendler (1959). All values were corrected to sample size of 50 mg. Counting efficiency with the procedure is of the order of 10 percent. Counting accuracy was made to a confidence level of 95 percent. The subsamples of leaves and twigs represented between 5 percent and 10 percent of all those on the plant, but for each subsample a precise number of leaves was collected and an accurate estimate of those remaining on the

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plant was made so that a reasonably accurate assessment of the total ^{14}C fixed by the plant could be determined. Part of these plants (approximately half) were removed from the soil and separated into individual roots, stems, and leaves in December 1973 and January

1974 (during the dormant season). The rest of the plants were removed in June 1974 and treated similarly. This sampling was after the spring new growth period. Activity of ^{14}C and weights of plant parts were obtained for all plants.

TABLE 1. ^{14}C status of plants from Mercury Valley, exposed to $^{14}\text{CO}_2$ in May 1973.

Species	Initial total ^{14}C fixed $\times 10^3$ cpm	% of ^{14}C remaining			
		Roots	Stems	Leaves	Total
<i>Larrea tridentata</i>	2529	10.3	14.7	12.8	37.8
<i>Atriplex confertifolia</i>	3340	3.0	18.9	18.4	40.3
<i>Ambrosia dumosa</i>	2095	5.2	7.1	4.3	16.6
<i>Krameria parvifolia</i>	622	14.1	51.7	0.0	65.8
<i>Atriplex confertifolia</i>	2051	2.9	21.8	11.2	35.9
<i>Ambrosia dumosa</i>	1621	9.7	53.9	0.7	64.3
<i>Acamptopappus shockleyi</i>	1343	7.6	45.8	0.0	53.4
<i>Larrea tridentata</i>	2690	11.8	16.1	8.3	36.2
Means	—	8.1	28.8	5.8	44.9
<i>Larrea tridentata</i>	835	7.3	7.6	4.9	19.8
<i>Atriplex confertifolia</i>	2600	3.5	20.5	5.7*	29.7
<i>Ambrosia dumosa</i>	914	5.2	41.8	8.9*	55.8
<i>Ambrosia dumosa</i>	2039	8.7	25.6	3.4*	37.7
<i>Ambrosia dumosa</i>	2022	ND	46.2	8.0*	ND
<i>Acamptopappus shockleyi</i>	1277	3.9	23.7	6.5*	34.0
Means	—	5.7	27.6	6.7*	35.3

*These values represent retranslocation from old stems and roots to new growth.

ND is not determined.

+ leaves were dead.

TABLE 2. ^{14}C status of plants from Rock Valley, Nevada, exposed to $^{14}\text{CO}_2$ in April 1973.

Species	Initial total ^{14}C $\times 10^3$ cpm	% ^{14}C fixed remaining			
		Roots	Stems	Leaves	Total
<i>L. andersonii</i>	960	40.4	31.9	—	72.3
<i>G. spinosa</i>	999	26.9	34.2	—	61.1
<i>C. lanata</i>	2397	10.5	21.5	3.1	35.1
<i>A. confertifolia</i>	2092	7.9	12.7	10.7	42.3
<i>L. pallidum</i>	909	29.4	28.3	—	57.7
Mean	—	23.0	27.9	—	53.7
<i>L. andersonii</i>	988	26.9	29.5	1.3*	57.7
<i>G. spinosa</i>	1226	13.3	39.4	7.3*	60.0
<i>C. lanata</i>	1959	13.6	44.6	4.9*	63.1
<i>A. confertifolia</i>	2193	4.6	12.8	2.9*	20.3
<i>L. pallidum</i>	792	19.8	16.4	1.0*	37.2
Mean	—	15.6	28.5	4.0*	47.7

*These values represent retranslocation from old stems and roots to new growth following dormancy.

RESULTS AND DISCUSSION

The amount of $^{14}\text{CO}_2$ fixed in the 14 perennial plants exposed to $^{14}\text{CO}_2$ in Mercury Valley in May 1973 and the 10 in Rock Valley in April 1973, together with the distribu-

tion among plant parts in either December 1973 or May or June 1974, are in Tables 1 and 2. From 17 to 65 percent of the ^{14}C remained in the plants at sampling time, depending on time and location. This was the range for both 7 and 13 months at each of

Table 1 continued.

% relative distribution of ^{14}C			Dry wt g/plant			Root + stem %	g new leaves that could have come from roots or stems
Roots	Stems	Leaves	Roots	Stems	Leaves		
Excavated in December 1973							
27.2	38.9	33.9	21.0	21.2	8.8	49.8	—
7.4	46.9	45.7	20.2	44.2	45.4	31.4	—
31.3	42.8	25.9	45.9	69.9	10.0*	39.6	—
21.4	78.6	0.0	120.4	95.5	0.0	55.8	—
8.1	60.7	31.2	12.1	26.0	12.1	31.8	—
15.1	83.8	1.1	29.2	26.0	4.3	52.9	—
14.2	85.8	0.0	15.6	28.0	0.0	35.8	—
32.6	44.6	22.8	85.0	92.0	16.0	41.0	—
19.7	60.3	20.0	—	—	—	46.6	—
Excavated in June 1974							
36.9	38.4	24.7	128.8	122.7	62.0	51.2	15.3
11.7	69.0	19.2°	87.6	137.0	123.0	39.0	23.6°
9.3	74.9	15.9°	47.0	65.1	16.1	41.7	2.6°
23.1	67.9	9.0°	75.6	76.0	43.0	49.9	3.9°
ND	ND	ND	ND	70.0	37.9	ND	ND
11.5	69.7	19.1°	25.1	35.2	22.2	41.7	4.2°
18.5	64.0	17.5°	—	—	—	44.7	—

Table 2 continued.

% relative distribution of ^{14}C			Dry wt g/plant			Root + stem %	g new leaves that could have come from roots or stems
Roots	Stems	Leaves	Roots	Stems	Leaves		
Excavated in December 1973							
55.9	44.1	—	108.9	77.1	—	57.4	—
44.0	56.0	—	76.4	58.5	—	56.6	—
29.9	61.3	8.8	20.6	17.0	14.9	54.3	—
18.7	56.0	25.3	26.1	56.0	20.0	31.8	—
51.0	49.0	—	59.9	18.6	—	76.3	—
39.9	53.3	6.8	—	—	—	55.4	—
Excavated in May 1974							
46.6	51.1	2.3°	87.9	99.4	15.7	46.9	0.4°
22.2	65.0	12.2°	51.2	77.1	23.5	39.9	2.9°
21.6	70.7	7.8°	112.2	114.3	21.8	49.6	1.7
21.7	63.1	14.3°	40.4	58.7	25.3	40.8	3.6°
53.2	44.1	2.7°	147.6	36.3	5.7	80.3	0.2°
33.3	58.8	7.9°	—	—	—	51.5	—

the areas studied. These values are of interest. In a companion study with *Larrea tridentata* (Sesse & Moc. ex DC.) Cov., about 10 percent of the ^{14}C label remained in the plants 40 months after labeling. Losses each year would come through respiration, abscised leaves, and fruit production.

Small quantities (3 to 20 percent) of the ^{14}C remaining in the plants were present in the spring leaves of deciduous plants that had become defoliated in the fall and winter. This means that from 3 to 20 percent at least of the new leaf growth was derived from C coming from old stems and roots. The remainder came from new CO_2 fixation. Be-

TABLE 3. Distribution of ^{14}C in roots of plants from Mercury Valley, Nevada, excavated seven months following exposure of leaves to $^{14}\text{CO}_2$.

<i>Larrea tridentata</i> —Mercury Valley—December 1973 (2,690,000 cpm ^{14}C fixed)													
Depth from surface	Length of root, cm											Dry weight of roots g	
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110		
Root	cm	cpm/g dry weight											
Main	—	4580	8280	2740	2480	2080	1960						18.16
A	2	2640	2480	3220	3760	3800	3840	4080	5620				2.99
B	3	2500	2420	2740	2860	4300	4020	3780					4.61
C	2	760	920	1320	1300	1300							0.33
D	6	2720	2860	3140	3220	3340	3020	2840	2920				3.12
E	7	4000	3820	3780	3920	4600							0.54
F	2	2760	2460	2080	2100	2180	2020	1840					1.62
G	10	2220	2180	2120	2300	3040	2520	1960					4.11
H	3	3940	6050	8020	9040								1.65
I	8	2980	2900	3120	3300	3240	3080	3680	3840	3740	3600	3540	8.01
J	11	2280	2080	2240									2.09
K	9	6160	6380	6200	6680								1.97
L	3	4660	4520	2220	4040	4260	3640	3600	3500	3360			12.88
M	5	6680	6960	6560	6220	5520	5180						3.13
N	6	5340	4540	4420	4460	4280	4120	4180	4280				0.82

Miscellaneous and fine roots 1140 cpm/g dry wt (7.8 g); litter 4640 (23.4 g); leaves 13,920 (16.0 g); stems 4720 (92.0 g).

<i>Atriplex confertifolia</i> —Mercury Valley—December 1973 (3,340,000 cpm ^{14}C fixed)													
Depth from surface	Length of root, cm											Dry weight of roots g	
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90				
Root	cm	cpm/g dry weight											
Main	—	3440	2440	2460	2920	3880	4060						10.77
A	4	2400	2200										0.31
B	8	11020	13280	12100	13000	12560	13280	12980	12020	12050			0.19
C	8	6980	7000	8200	10580	10360	10220	11060	10200				0.15
D	6	22820	16800	14200	15420	16200	17000	15210	15280	19200			1.03
E	4	3080	3000	2980									0.30
F	22	1100	1220										0.27
G	20	5980	5820	5700	5600	5460							0.33
H	30	2100	2160	2170	2220								0.24
I	off D	720	780	720	340	220							0.34
J	27	2340	2200	2080	2610	2740							2.11
K	29	2040	1760	1780									0.11

Fine roots 4820 cpm/g dry wt (0.2 g); crown pieces 2100 (3.9 g); dead stump 200 (14.9g); miscellaneous roots 3000 (1.3 g); litter 9540 (30 g); leaves 13520 (45.4 g); stem 15420 (40.3 g).

Table 3 continued.

<i>Ambrosia dumosa</i> —Mercury Valley—December 1973 (1,621,000 cpm ¹⁴ C fixed)												
Depth from surface	Length of root, cm										Dry weight of roots g	
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100		
Root	cm	cpm/g dry weight										
Main	—	5320	6340	6500	7820	4920						10.70
A	9	5840	6080	6160								0.19
B	9	8780	8080	7700	7280	5500	4820					0.99
C	9	5640	6800	5500	5580	6000	6440	5200	4860	6050	7640	4.51
D	11	4520	4960	5520	5500	5660	4320	4860	5620			2.56
E	18	5860	5960	5780	6200	6520						1.13
F	16	3820	4200	4620								0.71
G	19	1216										0.19
H	25	7140	7500	8460	5940							9.80

Miscellaneous and fine roots 2020 (3.6 g); litter 16540 (4.9 g); no leaves; stem 33600 (26.0 g).

<i>Atriplex confertifolia</i> —Mercury Valley—December 1973 (2,051,000 cpm ¹⁴ C fixed)							
Depth from surface	Length of root, cm						Dry weight of roots g
	0-10	10-20	20-30	30-40	40-50		
Root	cm	cpm/g dry weight					
Main	0	6720	4500	4960	5100	3900	6.91
A	4	8540	9480	17800			0.11
B	9	4240	6020	7433	7680	9000	0.33
C	11	4180	4020	3800	3720		0.87
D	25	3960	4020	4160			0.30

Miscellaneous and fine roots 2700 cpm/g dry wt (1.9 g); litter 13,680 (10.3 g); leaves 19,000 (12.1 g); stems 17,100 (26.0 g).

<i>Ambrosia dumosa</i> —Mercury Valley—December 1973 (2,095,000 cpm ¹⁴ C fixed)							
Depth from surface	Length of root, cm					Dry weight of roots g	
	0-10	10-20	20-30	30-40			
Root	cm	cpm/g dry weight					
Main	—	1120	840	1220	720	25.28	
A	6	2460				0.04	
B	10	640	760	660		2.11	
C	10	940	1080	1200		1.26	
D	10	1800	1600	1580		0.78	
E	10	1760	1800	2720		0.63	
F	11	1140	1220	1300	760	0.60	
G	13	1740	2440	2020		0.85	
H	10	1640	1760	2020		0.99	
I	15	3100	3840	4940		1.09	
J	15	1900	1680	2220		0.58	
K	17	860				0.13	
L	20	200	120	100	20	1.24	
M	20	1680	1960	1800	1860	0.81	
N	25	100	20			0.24	
O	25	160	100			0.20	
P	27	500	398			0.47	

Crown 1260 cpm/g dry wt (7.4 g); shoots 2880 (79.9 g); fine roots 1180 (2.3 g)

Table 3 continued.

<i>Larrea tridentata</i> —Mercury Valley—December 1973 (2,529,000 cpm ¹⁴ C fixed)								
Root	Depth from surface cm	Length of root, cm						Dry weight of roots g
		0-10	10-20	20-30	30-40	40-50	50-60	
		cpm/g dry weight						
Main	—	14600	9900	3580				
A	1/2	67380	6360	2440				
A ₁	1/10	9360	500		2020			
A ₂	1/10	5940	740					
B	2/10	13540	6900	5240				
C	1/2	3660	2100					
D	1	21040	20620	22320	15280			
E	1/2	—	—	(not counted)				
F	3	500						
G	3	27660	23940	25120	23500	22580	23360	21560
H	13	8620	8020	9120	9000	10400		
I	20	9560	9240	9860	10720	9000	8420	
		cpm/g dry weight						
Root	Depth from surface cm	70-80	80-90	90-100	100-110	110-120	120-130	Dry weight of roots g
Main	—							7.16
A	1/10							0.67
A ₁	1/10							0.10
A ₂	1/2							0.17
B	2/10							0.26
C	1/2							0.16
D	1							0.72
E	1/2							0.36
F	3							0.09
G	3	21000	20280	21020	21600	21780	21760	3.50
H	13							0.72
I	20							1.87

Crown cpm/g dry wt 10,000 (2.3 g); leaf 36,860 (8.8 g); stem 18640 (21.2 g); fine roots 2740 (2.5 g).

<i>Acamptopappus shockleyi</i> —Mercury Valley—December 1973 (1,343,000 cpm ¹⁴ C fixed)								
Root	Depth from surface cm	Length of root, cm						Dry weight of roots g
		0-10	10-20	20-30	30-40	40-50		
		cpm/g dry weight						
Main	—	4200	8660	3660				5.21
A	3	—	—	—		(not counted)		0.03
B	3	—	—	—		(not counted)		0.04
C	3	—	—	—		(not counted)		0.04
D	2	—	—	—		(not counted)		0.02
E	3	—	—	—		(not counted)		0.05
F	5	—	—	—		(not counted)		0.06
G	8	6220	5620	5420	5880	5600		1.37
H	7	14520	15220	18760				0.37
I	10	6660	8040	10060				0.73
J	10	6500	10900	8800				0.97
K	11	1560	1040	300				0.45
L	13	7880	8940					0.80
M	16	6660	9880	9860	23360			0.65
N	15	4600						0.25

Miscellaneous and fine roots 6540 (2.0 g); Litter 5760 (2.3 g); no leaves; stem 21980 (28.0 g).

Table 3 continued.

<i>Krameria parvifolia</i> —Mercury Valley—December 1973 (622,000 cpm ¹⁴ C fixed)											
Depth from surface		Length of root, cm									
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Root	cm	cpm/g dry weight									
Main	—	320	540	1360							
A	7	260	220	160	160	160	300	240	80	80	100
B	4	8280	8000								
C	3	12640									
D	10	980	820	680	780	1540	2010	3560	5920		
E	13	1100	620	400	340	120	40				
F	6	500	480	460	500	540	720	780			
G	14	1320	980	760	920	880	1080				
H	4	2560	2000	1460	1400	1480					
I	12	360	340	380	340	660	620	520	400	320	280
J	9	1260	1300	1720	1610	880	780	720	780	760	1160
K	12	700	620	540	600	700	760	900	2020		
L	10	740	740	780	700	720	680	720	960	1040	1020
M	7	340	280		420	680		220		300	180

Depth from surface		Length of root, cm										Dry weight of roots g
		100-110	110-120	120-130	130-140	160-170	170-180	180-190	200-250	250-300		
Root	cm	cpm/g dry weight										
Main	—											56.76
A	7											3.98
B	4											0.32
C	3											0.19
D	10											2.15
E	13											1.31
F	6											1.96
G	14											1.40
H	4											0.53
I	12											6.72
J	9	1160	1160									17.13
K	12											2.54
L	10	960										4.80
M	7		220	200	180	240	360	500	300	380		32.25

Litter 7060 cpm/g dry weight (18.8 g); miscellaneous and fine roots 660 (1.0 g); no leaves; stem 5980 (95.5 g).

tween December and May and June there seemed to be greater loss of the ¹⁴C from roots than from leaves, but this may not be related to the transfer to the new leaves.

The distribution of the ¹⁴C in segments of individual roots at sampling time, 7 to 13 months after exposure to ¹⁴CO₂, is in Tables 3 to 6. Although most roots were reasonably uniformly labeled for a given plant, some roots had higher activities than the majority and others were less labeled. The high specific activity of roots may represent roots being formed at the time of labeling, and the low specific activity roots may be those formed

after the time of labeling. Usually, each root was uniformly labeled along its length with little indication of a pulse point.

It seems that old roots were labeled to some degree or other. Our expectation of finding new unlabeled roots was not fulfilled. New roots, like new leaves, seemed to have a fraction of their carbon coming from old plant parts so that they were labeled also. Old carbon then is at least in part labile in both stems and roots among the winter deciduous perennials. It may be less so in the evergreen *L. tridentata*, which seems to conserve carbon and use very little of it in new

TABLE 4. Distribution of ^{14}C in roots of plants from Mercury Valley, Nevada, excavated one year after exposure of leaves to $^{14}\text{CO}_2$.

<i>Larrea tridentata</i> No. 4—Mercury Valley—June 1974 (835,000 cpm ^{14}C fixed)										
Depth from surface		Length of root, cm								
Root	cm	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
		cpm/g dry weight								
Main	—	340	160	280	260	200	160	180		
A	8	920	920	920	920	920	1000	1120	1320	1000
B	10	440	440	500	660	620	940	680	1160	1200
C	30	500	520	420	440					
D	30	240	200	160						
E	33	160	160							
F	33	200	200	320	480	500	640	700	720	680
F	39	560	520	360	140					

<i>Atriplex confertifolia</i> —Mercury Valley—June 1974 (2,600,000 cpm ^{14}C fixed)										
Depth from surface		Length of root, cm								Dry weight of roots g
Root	cm	90-100	100-110	110-120	120-130	120-140	140-150	150-160	170-180	
		cpm/g dry weight								
Main	—									56.48
A	8	700	860	1040	920	800	940			28.03
B	10	1160	1100	1040	1000	860	800	800	680	7.00
C	30									1.14
D	30									0.97
E	33									0.39
F	33	640	500	280						13.00
F	39									0.45

Miscellaneous roots cpm/g dry wt 260 (5.0 g); leaves 660 (62.0 g); small stem 1000 (26.7 g); large stem 380 (96.0 g).

<i>Ambrosia dumosa</i> —Mercury Valley—June 1974 (2,039,000 cpm ^{14}C fixed)										
Depth from surface		Length of root, cm								Dry weight of roots g
Root	cm	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
		cpm/g dry weight								
Main	—	1220	1980	1620	680	740	700			30.09
A	6	100	120							0.05
B	7	200								0.06
C	14	1760	1260	1520	1340					3.78
D	16	3080	2460	2900	2300	2400				0.40
E	16	680	500	510	120					0.55
F	18	1000	1780	1040	880	920				4.17
G	22	3800	3400	4200	3000					2.50
H	24	1200	860							0.42
I	22	1200	440							0.06
J	27	720	4450							0.09
K	27	1100	1940	1340	1120					0.32
L	21	1440	1140	1140	1020	1060	920	940		2.02
M	29	1100	1325							0.15
N	19	1200	800	660	720					2.15

Miscellaneous roots 1980 (3.9 g); leaves 1200 (123.0 g); stem 3520 (90.0 g); stem crown 20 (37.0 g); litter 2620 (83.0 g).

Table 4 continued.

Main	—	2300	2360	2700	1840	1440	1460	1160			32.57
A	8	5520	6080	7320							1.11
B	9	3280	4340	4960	5040						0.74
C	10	3400	4160								0.26
D	8	2500	2120	1180	2180	1400					4.14
E	12	2340	2240	2400	3600						1.69
F	12	4160	3900	2680	4700	4380	4700	4380			3.81
G	14	2380	2760	2820	2640	2320	2120	2460	3300		5.59
H	12	5380	5320	4980	4580	5300	4860	4540	5240	4460	3.35
I	13	680	520	540	700						1.77
J	14	1920	1540								0.45
K	18	2640	3000	3360	3340	3700	3200	2100			5.42
L	20	3520	2260	3160							1.41
M	25	1100	1240	1240	1060	1140					1.16
N	26	1480	1120	700	680	720	1360	1278			2.52

Miscellaneous roots cpm/g dry wt 1180 (1.0 g); leaves 1600 (43.0 g); small stem 9680 (27.6 g); large stem 5120 (48.4 g); litter 800 (5.3 g).

<i>Acamptopappus shockleyi</i> —Mercury Valley—June 1974 (1,277,000 cpm ¹⁴ C fixed)									
Root	Depth from surface	Length of root, cm							Dry weight of roots g
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	
Root	cm	cpm/g dry weight							
Main	0	2020	1820	1720	2120	2340	2360		14.94
A	3	3930	3750	2000					0.05
B	4	2560	21000						0.04
C	5	980							0.08
D	6	1380	4000						0.07
E	5	4420							0.08
F	9	2520							0.04
G	20	1360	1300	1860	2780				0.70
H	20	2460	2680	3520					0.48
I	20	1000	960						0.30
J	20	1860	1640	2060	2320	3700	5720	5300	0.81
K	23	2120	2400	2400					0.42
L	26	2120	2740	2540	2820	3500			1.02

Miscellaneous roots cpm/g dry wt 2360 (1.7 g); miscellaneous roots 446 (0.7 g); leaves 3740 (22.2 g); small stems 9940 (15.0 g); large stems 7580 (20.1 g).

<i>Ambrosia dumosa</i> —Mercury Valley No. 7—June 1974 (914,000 cpm ¹⁴ C fixed)									
Root	Depth from surface	Length of root, cm							Dry weight of roots g
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	
Root	cm	cpm/g dry weight							
Main	--	1420	1500	600	1020				16.68
A	10	480	880	900					1.36
B	9	1840	2060	2020					0.75
C	12	120	42						0.21
D	10	6091							0.08
E	13	1640	700	540					0.54
F	17	0	0	0	0				1.52
G	16	0	0	0	0				2.42
H	16	780	1000	760	420	240			4.45
I	18	860	900	800	560	720	660		2.65
J	16	1540	1480	1480	1120				2.65
K	16	1440	1300	1220	1220	1400	1500	2260	2.66
L	20	1260	1120	800	960	1780			0.24

Leaves 5040 cpm/g dry wt (16.1 g); small stems 22000 (15.9 g); large stems 4360 (49.2 g).

TABLE 5. Distribution of ^{14}C in roots of plants from Rock Valley, Nevada, excavated eight months following exposure to $^{14}\text{CO}_2$.

<i>Ceratoides lanata</i> —Rock Valley—December 1973 (2,397,000 cpm ^{14}C fixed)											
		Length of roots, cm									Dry weight of roots g
Root	Depth from surface cm	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	
		cpm/g dry weight									
Main	—	14280	12300	10940	7920	7960	10800	12320	5260	5200	8.08
A	3	30100	26400	27200	25800						0.09
B	5	17960	17200	18800							0.12
C	9	15820	17600	18200	20740	16800					0.23
D	10	19020	19600	18100	15210	15300					1.19
E	9	16980	18900	23100	27600	22800					0.26
F	11	10180	14600	14100	33800	30000					0.11
G	14	11040	11460	10980	12100	10160					0.82
H	15	12280	11160	10060	9920	8060	7600	7480	7300		1.85

Miscellaneous and fine roots 11000 cpm/g dry wt (5.2 g); stems 30380 (17.0 g); leaves 22420 (14.9 g); litter 4220 (14.9 g).

<i>Atriplex confertifolia</i> —Rock Valley—December 1973 (2,092,000 cpm ^{14}C fixed)											
		Length of root, cm									Dry weight of roots g
Root	Depth from surface cm	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	
		cpm/g dry weight									
Main	—	8200	4740								10.13
A	9	3660	3620	4260	4320						0.42
B	5	15260	9820	4860	4700	4720					0.38
C	13	1180	1300	1100	1200						0.17
D	17	2060	2125	1820	1700						0.46
E	18	40	20								0.11
F	20	6720	6000								0.35
G	18	8980	7210	6620	6240	6000	5920				1.09
H	18	4480	4162	3200	2080	3602	3200	4060	3980	5620	2.46
I	14	2760	3000	3700	3280	3620	2810	2300	2500		3.35

Litter 12720 cpm/g dry wt (13.3 g); miscellaneous and fine roots 4240 (3.8 g); stem 8860 (56.0 g); leaves 11220 (20.0 g).

<i>Lycium pallidum</i> —Rock Valley—December 1973 (909,000 cpm ^{14}C fixed)										
		Length of root, cm								
Root	Depth from surface cm	0-10	10-20	20-30	30-40	40-50	50-60	60-70		
		cpm/g dry weight								
Main	—	3460	3780	4016	3910	3880	4520	4620		
A	3	1660	1580							
B	6	1400	1400							
C	8	4120	2620	2420	1700	1680	1640			
D	8	2740	2700	1720	1700	420	302			
E	10	2810	2740							
F	12	6860	6600							
G	18	4440	4000	4300	4820	5060	4340	2800		
H	33	1360	1400	1800						
I	40	4920	5420	7860	6040	3540	4040	4200		
J	45	5560	4980							
K	55	5420	5210	5200	5000	4880				
L	36	7860	7520	7660	7840	7900	9500	9400		

Table 5 continued. *Lycium pallidum* continued.

Root	Depth from surface cm	Length of root, cm					Dry weight of roots g
		70-80	80-90	90-100	100-110	110-120	
Main	—	5120	5000	4500	3020		28.50
A	3						0.09
B	6						0.23
C	8						0.65
D	8						0.45
E	10						0.08
F	12						0.12
G	18	2700					2.61
H	33						0.57
I	40	4460	4700	4640	3820	3700	7.63
J	45						0.17
K	55						1.19
L	36	9020	8300				1.56

Dead crown material 20 (68.4 g); live crown material 5400 (5.1 g); live roots 2800 (0.4 g); stems 4280 (13.5 g); litter 6180 (4.7 g); miscellaneous roots 2560 (7.9 g).

Root	Depth from surface cm	<i>Grayia spinosa</i> —Rock Valley—December 1973 (999,000 cpm ¹⁴ C fixed)							Dry weight of roots g	
		Length of root, cm								
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	
Main	—	4240	5140	3640	2560	2660				17.99
A	5	960	40							0.13
B	5	5120	3620	3500	3460	3480	3420	3460	3410	5.03
C	4	12280	11680	12100	11920	13400	16320			0.84
D	5	9840	8120	6600	5580	4440	4310	4014		3.86
E	13	9260	9410	9600	9980	9620	8240	9210	10460	2.26
F	5	23140	22160	21000	19800	19820				0.76
G	10	2660	2600	2560	2300	2160	3000	3500		0.41
H	15	60	60	0	0					0.20
I	19	5400	5480	5180	6900	7800				1.75
J	30	2720	2600	2580	2260	2020				1.41
K	40	2080	1960							0.25
L	38	2580								0.25
M	35	2280	2200	2420	2580	2620				3.17

Miscellaneous and fine roots cpm/g dry wt 1040 (2.8 g); litter 9580 (12.9 g); stem 5780 (55.8 g).

Root	Depth from surface cm	<i>Lycium andersonii</i> —Rock Valley—December 1973 (960,000 cpm ¹⁴ C fixed)								
		Length of root, cm								
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	
Main	—	1020	900	720	700	700	880	750	600	
A	6	11320	11000	11900	12000	13320				
B	6	220	180	40	50	60				
C	16	3000	3000	3200	3100					
D	15	2140	2240	2060	2100	2300	2500	3060	2980	
E	13	1260	1420	1740	1920	2320	3300	4260		
F	3	10280	8850	8170	6080	6280				
G	24	360	240	180	40	60	40			
H	4	2700	2680	2660	2640	2540	2400			
I	8	1820	1780	2060	2180	2400	2200	2160		
J	8	2860	2380	2000	2240	1900	3660			
K	3	5980	5400	4260	4820	5560	7900	8020	8140	
L	3	5320	5100	6140	6320	7220	7260	8900	11020	
M	10	11080	7820	6400	4840	4520				
N	3	60	80	80	140	240	180	320	180	
O	20	160	100	100	80	0	40	200	360	
P	5	2080	3000	4720	4700	4680	3800	3680	3700	

Table 5 continued. *Lycium andersonii* continued.

Root	Depth from surface cm	Length of root, cm							Dry weight of roots g
		80-90	90-100	100-110	110-120	120-130	130-140	140-150	
Main	—	860	750	700	620	190	600	280	39.31
A	6								1.05
B	6								1.02
C	16								1.16
D	15	2620							2.63
E	13								5.57
F	3								0.48
G	24								4.14
H	4								1.05
I	8								5.45
J	8								1.27
K	3	9060	9960	13240					7.37
L	3	8000							2.62
M	10								0.24
N	3								10.73
O	20	100	80	60					2.47
P	5								3.05

Stem crown materials 2120 (34.3 g); dead main root 5020 (35.5 g); litter 1700; stem 4820 (42.8 g).

growth.

A summary of the numbers of roots found with low medium and high rates of labeling is given in Table 7. There were a few roots with high amounts of label at the tip or high label near the point of attachment to the

main root. This is indicative of some pulse effect.

The fact that ^{14}C is uniformly distributed among different roots implies exchange and equilibrium.

TABLE 6. Distribution of ^{14}C in roots of plants from Rock Valley, Nevada, excavated one year after exposure of leaves to $^{14}\text{CO}_2$.

Root	Depth from surface cm	<i>Atriplex confertifolia</i> —Rock Valley—May 1974 (2,193,000 cpm ^{14}C fixed)							Dry weight of roots g	
		Length of root, cm								
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	
Main	—	2660	3200	2140	1560	1440	1380			24.10
A	7	1009								0.05
B	10	1480	1840	1610						0.24
C	9	4370	6770	6200	6100	6000				0.19
D	9	8700	7670	10520	9370	17435	21200			0.26
E	8	1020	1230	1650	1920	2570				0.23
G	18	1620	3760	4840	8430	8080				0.96
H	7	1900	1740	1280	1200	1120	1020	1020	700	2.48
I	18	1240	1140	900	920	1180	1060	660		1.13
J	15	2560	2340	2100						0.49
K	13	6860	7060	8720	8500	6920	6700	6040		1.05
L	16	2460	880							0.33

Miscellaneous roots cpm/g dry wt 1340 (3.6 g); large stem 5340 (25.9 g); small stem 4380 (32.8 g); leaves 2540 (25.3 g); litter 10820 (13.8 g).

Table 6 continued.

<i>Grayia spinosa</i> —Rock Valley—May 1974 (1,226,000 cpm ¹⁴ C fixed)												
Root	Depth from surface cm	Length of root, cm										Dry weight of roots g
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
Main	—	2580	2260	1500	1660	1320	1300	1360	1480	1740	2320	20.98
A	5	3720	3520	3400	3460	3080	2545					1.17
B	4	2920	1740	5962								0.24
C	5	7830	3043									0.09
D	6	2310	1130									0.11
E	5	2840	1882	643	93							0.23
F	7	3820	3100	2920	2200	2400	2280	2300				9.94
G	5	8960	7960	5940	4980	3980	4620					4.60
H	11	3220	2840	3540	5820							0.93
I	9	4160	4500	2900								1.23
J	12	2680	2680	2340								1.20
K	13	3780	3040	2050								0.26
L	17	1700	1680	2060								0.42
M	21	1980	1300									0.20

Miscellaneous roots cpm/g dry wt 4320 (2.9 g); small stem 4200 (28.2 g); large stem 7440 (48.9 g); leaves 3780 (23.5 g); litter 160 (41.3 g).

<i>Ceratoides lanata</i> —Rock Valley—May 1974 (1,959,000 cpm ¹⁴ C fixed)												
Root	Depth from surface cm	Length of root, cm										Dry weight of roots g
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
Main	—	3500	2000									26.28
A	7	4000	4710	18040	4800	2080	1160					0.16
B	6	5350	8750	11120	2730	32900	1761					0.31
C	6	18740	19100	13300								0.34
D	10	2960	2660	1580	1420	1800	3020					0.77
E	10	2740	1240	1640	860	860						0.73
F	8	7220	6840	7760	7060	4900	4200	2900	3000	4200	3080	1.24
G	10	4890	6040	8640	25120	5590						0.19
H	9	5340	4720	6320	4740	4580	4460	3590				0.46
I	9	3320	3220	2020	2120	2420	1820	1840				2.86
J	8	18430	16400	11560	7150							0.25
K	10	12520	9060	8960	6580	6060						0.46
L	15	3880	2600	2680	3520							0.48
M	6	4980	3980	2080	1560	1820	940					1.21
N	8	3420	2200	2640	2640	1400						1.15
O	10	1760	2780	2740	3060							1.34
P	18	1380	1200	1100	880							0.95
Q	11	10120	8100	5540	4520							0.34
R	8	240	250	143	357	294						0.27
S	12	1960	1740	1920	1560	1560	1420					0.83
T	8	5440	4520	4780	4360	3520	3260					0.85
U	11	6180	4840	4080	3240	2280	2330					0.59
V	8	4340	3940	3100	4320							0.60
W	9	4960	4880	5380	6220	6580	6260	5480				0.70
X	15											
Y	8	1260	1160	1480	1210							0.25
Z	10	420	40	40								1.30

Other roots 1360 cpm/g dry wt (43.2 g); leaves 4440 (21.8 g); miscellaneous roots 2940 (9.6 g); small stem 10560 (59.9 g); large stem 4440 (54.4 g); litter 12,880 (1.1 g).

Table 6 continued.

<i>Lycium pallidum</i> —Rock Valley—May 1974 (792,000 cpm ¹⁴ C fixed)									
		Length of root, cm							
	Depth from surface	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
Root	cm	cpm/g dry weight							
Main	—	1400	620	300	600	700	700	720	720
A	10	1420	980	540	540	580	620	620	640
B	17	220	240	60	160	140	160		
C	2	280	200	160	220	220			
D	22	480	380	540	956	957	1675		
E	22	360	400	400	160	160			
F	20	200	375	160	100	120	191		
G	29	580	560	560	560	600	660	540	540
H	23	160	106	300					
I	25	220	180	180	120				
J	25	540	560	640	680	560	620	740	800
K	25	200	186						
L	26	240	240	260	260				
M	6 (large)	3680	2720	3740	4260	3580	3660	3340	3700
N	9 (off M)	1040	400	595	538				
O	4 (off M)	1880	1460	1120	1220				

		Length of root, cm						Dry weight of roots g
	Depth from surface	80-90	90-100	100-110	110-120	120-130	130-140	
Root	cm	cpm/g dry weight						
Main	—	800	840	620	520	620	620	80.97
A	10	740	720					2.24
B	17							4.13
C	2							0.72
D	22							0.97
E	22							1.88
F	20							0.55
G	29	580	580					11.26
H	23							0.19
I	25							0.79
J	25	900	620					3.56
K	25							0.15
L	26							1.05
M	6 (large)	3800						14.52
N	9 (off M)							0.33
O	4 (off M)							0.77

Miscellaneous roots 140 cpm/g dry wt (4.2 g); dead crown 60 (62.7 g); small stem 4060 (5.4 g); large stem 3520 (30.9 g); leaves 1440 (5.7 g); litter 1420 (16.2 g).

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TABLE 7. Summary of labeling patterns of the roots from Table 5 and 6.

Species	Date sampled	No. of high S.A.** roots	No. of low S.A.** roots	No. of nonlabeled roots	No. of medium S.A.** roots
Mercury Valley					
<i>Larrea tridentata</i>	Dec. 1973	3	5	0	7
<i>Atriplex confertifolia</i>	"	3	6	0	3
<i>Ambrosia dumosa</i>	"	0	1	0	8
<i>Krameria parvifolia</i>	"	2	9	1	2
<i>Atriplex confertifolia</i>	"	2	0	0	3
<i>Ambrosia dumosa</i>	"	1	3	2	11
<i>Acaemtopappus shockleyi</i>	"	4	1	0	4
<i>Larrea tridentata</i>	"	5	1	0	4
<i>Larrea tridentata</i>	June 1974	0	5	3	0
<i>Atriplex confertifolia</i>	"	0	11	2	2
<i>Ambrosia dumosa</i>	"	0	2	3	8
<i>Ambrosia dumosa</i>	"	1	3	0	11
<i>Acaemtopappus shockleyi</i>	"	0	3	0	10
Rock Valley					
<i>Lycium andersonii</i>	Dec. 1973	5	2	4	5
<i>Crayia spinosa</i>	"	2	3	0	9
<i>Ceratoides lanata</i>	"	8	1	0	0
<i>Atriplex confertifolia</i>	"	2	0	1	
<i>Lycium pallidum</i>	"	2	5	0	7
<i>Lycium andersonii</i>	May 1974	0	4	1	11
<i>Crayia spinosa</i>	"	0	3	0	11
<i>Ceratoides lanata</i>	"	5	3	1	
<i>Atriplex confertifolia</i>	"	2	4	0	6
<i>Lycium pallidum</i>	"	0	5	3	8

*Some roots appeared to have a pulse or a demarcation in the distribution of the ^{14}C .

**S.A. is specific activity of ^{14}C .

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